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SAMPLING OF SOLID MATERIALS
BY CORING TECHNIQUES

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SAMPLING OF SOLID MATERIALS BY CORING TECHNIQUES

by

John R. Raymond

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INTRODUCTION

Material sampling may be required for quality control or to determine physical or chemical characteristics. In some cases, direct "grab" samples may be made on a process line or direct proportional samples taken. In other cases it is impossible or at least difficult to sample directly. Examples are: Sampling at the center of a large grain storage bin; obtaining representative earth samples during well drilling; and obtaining sludge samples from the bottom of a tank used for storage of high level liquid radioactive waste. In addition, undisturbed samples are sometimes required or desired to determine such characteristics as in-place permeability, porosity, or moisture content.

Core sampling techniques have particular applicability for remote or undisturbed material sampling. Core sampling is done by cutting, washing, abrading or displacing material away from a cylindrical central sample core. The core feeds into a hollow barrel or tube which protects and retains the sample. The core barrel is advanced into the material by rotational and/or compressive and impact forces applied through a drill rod to a bit or drive shoe mounted below the core barrel. Although coring techniques are used extensively to sample earth materials, the same methods may be used to successfully sample almost any material ranging from fluid mud and clay to solid steel.

The purpose of this report is to describe material core sampling methods, techniques and equipment, particularly those having application in sampling radioactively-contaminated materials.

Core Sampling Methods

Core samples of earth materials, concrete, tank sludge and other consolidated or unconsolidated substances may be obtained by either of two general methods: drive sampling or rotary sampling. The method used depends on the physical properties of the sampled material (e.g., hardness, friability, cohesiveness, solubility, etc.) and the length and diameter of the desired sample. The same basic equipment components are used with both methods:

1. A hollow bit to cut through the material.
2. A core barrel to contain the sample.
3. A core lifter or retainer to prevent the sample from falling out of the core barrel.
4. Drill rods to transmit energy to the bit.
5. A source of energy to effect bit penetration.

In the drive sampling method, the core barrel is driven into the sample material by impact of a heavy weight. In rotary sampling, the core barrel is drilled into the sample by rotation of the bit and core barrel while cuttings are flushed from the hole by flow of a fluid under pressure. The drive sampling equipment and techniques are much simpler than those used for the rotary coring method.

Drive Coring Equipment and Techniques

Figure 1 shows an exploded view of a typical drive sampling core barrel. The sampler consists of a drive shoe, core lifter, sample barrel and sampler

Figure 1

Split Tube Drive Sampler

head. The drive shoe or bit is hardened tool steel and is tough enough to break small rocks and pebbles without sustaining damage. The inside diameter (ID) of the bit is slightly smaller than the core barrel ID, and the core will pass into the barrel without undue friction or compaction. The core lifter or retainer has a number of spring fingers that allow easy passage of the core into the barrel but prevent return flow of the sample out of the core barrel. The core barrel, in this case, is a split-tube type that is held together by the drive shoe and the core barrel head. The sample is easily removed by unscrewing the drive shoe and head and "splitting" the core barrel. The head, in addition to clamping the core barrel together, provides a rod coupling and contains a ball check valve to vent fluid from the barrel. The check valve also assists in retaining the core. Figure 2 shows the assembled drive sampler. This sampler takes a 1-5/8 inch diameter by 2-foot long core.

Figure 3 shows operation of the drive sampling equipment. A length of heavy wall drive rod or casing is attached to the core barrel head. The drive head (a heavy steel collar) is attached to the drive rod, and a short section of rod that serves as a drive hammer guide is screwed into the top of the drive head. The drive hammer in this case is a 300 pound weight with a guide hole through the center. A jar-back collar is attached to the top of the guide rod. In operation, the drive hammer is repeatedly lifted by a winch and dropped against the drive head. The core barrel progresses downward as the sharpened steel shoe compresses and displaces the sample media. The sampling is completed when the core barrel has been driven its full length into the material. The weight is then raised against the jar-back collar and the core barrel jarred

Figure 2
Assembled Drive Sampler

Figure 3
Drive Sampling Operation

or lifted from the hole. The sampler may be rerun in the hole for progressive depth sampling as long as the material does not cave. When caving takes place, a separate casing may be driven in the hole to provide core barrel access.

The drive sampling technique is usually successful only with soft or unconsolidated porous media where the drive shoe can compress or displace the material. A limited amount of hard nodules in a soft matrix, such as pebbles or gravel in sand, can be tolerated. The hard particles will be sampled, displaced or broken up if the nodule size is smaller than the core barrel diameter. Large diameter objects, such as boulders, prevent core barrel progress. With proper use, nearly undisturbed samples may be taken by the drive method. Maximum practical sampling depth with drive coring equipment is about 50 feet in a soft material (sand, silt, clay, etc.) that will stand unsupported. When a casing is used, the sampling depth is limited only by the depth that the casing can be driven (up to 300 feet under favorable conditions).

The drive coring method has been used successfully at Hanford to sample earth materials ranging from sand and gravel to mud in waste disposal crib bottoms and shallow wells. Drive sampling equipment is commercially available in core barrel lengths of 18 to 30 inches with diameters from $1\frac{1}{2}$ to 4 inches. Special equipment may be fabricated in almost any length or diameter.

Rotary Coring Equipment and Techniques

Rotary core sampling equipment consists of a drill bit screwed to the end of a core retaining barrel, drill rods attached to the upper end of the core barrel, and a power source to rotate the rods and apply compressive

pressure on the bit. Generally, a high-pressure fluid pump and a source of water or other drilling fluid are also required. Many different types of rotary core bits are available for sampling a great variety of materials. Diamond set bits are used for hard materials such as granite, limestone and steel. Tungsten carbide or other hard metal-set bits are used for soft or unconsolidated substances such as sand, clay and talc. The core barrel may be simply a section of drill rod or it may be a more complex double-tube assembly.

Almost any material can be cored using the rotary method; but it is important, particularly with unconsolidated material, that proper techniques and equipment are used. Factors that affect coring are: bit, core lifter and core barrel design, rotary speed, bit pressure and drilling fluid type, viscosity, flow rate and pressure.

A single-tube core barrel and diamond-set, face discharge bit are generally used with hard substances. Amount of bit relief (the degree that the bit cuts a smaller diameter core than the core barrel ID) is not critical when coring hard materials. Almost any drilling fluid flow rate may be used as the drill cuttings are fine and are easily flushed out of the hole. Bit pressure may be as high as fluid cooling and drive power permit, and high or low rotary speeds can be used. Long corings (up to 20 feet long) may be made on a single run in hard materials.

Soft or unconsolidated material coring is more difficult. The core must be protected from washing by the drilling fluid. This is accomplished with a double tube core barrel. Figure 4 shows an exploded view of a typical

Figure 4

Double-Tube Rotary Core Barrel - Exploded View

small diameter, double-tube core barrel. Figure 5 shows the assembled sampler; a clay-type bit is pictured on this particular sampler. The double tube barrel consists of two concentric tubes; the drilling fluid is diverted to the bit between the outer tube and inner (sample) tube. The bit is mounted on the outer tube with minimum clearance between the inside bit shoulder and the bottom of the lifter case. The swivel, in theory, permits the inner sample barrel to remain stationary while the outer barrel and bit rotate. Strips of copper brazed to the end of the inner barrel provide a lower bearing. The double tube barrel and swivel arrangement prohibits excessive fluid flow either up or down the inner core barrel and prevents core washout. Bit type, drill feed rate, bit pressure and drilling fluid flow rate must be carefully selected and tailored to the physical properties of the unconsolidated material. Excessive drill feed rate or low drilling fluid flow rate prevents adequate sample lubrication and the core will then jam or block the bit, lifter case or core barrel. High fluid flow rate or low drill feed rate permits cutting of the unconsolidated material ahead of the bit and as a result, no material is fed into the core barrel. A clay type bit is often used for drilling in soft materials. This bit has an extension beyond the fluid outlet holes to prevent excessive washing of the cored material. Soft, porous material is always disturbed to some extent in the rotary coring process. Some fluid invasion and contamination of the sample also occurs.

Figure 6 shows a small rotary drill assembly used at Hanford. The equipment has been used to obtain core samples of waste tank bottom sludge and earth materials. It is also used to drill small diameter noncored, special test

Figure 5

Assembled Double Tube Rotary Core Barrel

Figure 6
Rotary Core Drill

wells. A modified chain-saw engine provides power for rotating the drill rod, and a hydraulic ram is used to apply compressive force to the bit. A small progressive cavity pump, driven by a gasoline engine, supplies drilling fluid pressure. The drill is mounted on the front of a 3/4-ton truck. The truck provides the necessary hold weight and permits operation mobility. Figure 7 shows the equipment in operation.

Rotary sampling equipment is commercially available in a wide variety of size and design. Bit and core barrel sizes vary from one inch to more than eight inches in diameter. Rotary coring may be done to almost unlimited depths. Core samples are taken in oil wells at greater than 20,000 feet below ground surface.

Acknowledgment

The assistance of V. L. McGhan and F. B. Steele in equipment testing and operation is greatly appreciated.

The pictured equipment was fabricated and assembled by Diamond Drill Contracting Co., Spokane, Washington.

Figure 7

Rotary Drill Operation

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